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THE GREAT BASIN.

BY

WM. H. BREWER.

" The Great Basin " is the name popularly applied to a region of the Western United States lying between the Sierra Nevada and the Wahsatch Mountains. It has no one single character which does not belong to some other portion of the globe, yet it constitutes the most distinctive geographical feature of the North American continent. It is an area of interior drainage, that is, none of its streams flow to the sea. Such areas are found in the other continents, but this one has a combination of features which belongs to it alone. Even if this was not the case, from its position within our own country and because of its actual character, it has for us an especial geographical interest.

There is a large and rapidly growing literature relating to this region, but the most of it relates either to special features or else is a narrative of travel. I know of no recent and general description of the basin as a whole, therefore in this lecture I purpose to bring together items of common information and to consider it as a geographical feature of our country, rather than to give you the results of recent original exploration. My own work in the basin was done long before any part of its present railroads was built and was confined to the Western edge.

Moreover, the more important observations I then made have been published elsewhere in connection with the various scientific objects for which those explorations were made. I have only seen the other portions of it as the passing traveller sees it since railroads have penetrated that country.

But let me here say, the traveller of to-day who goes whirling across it by express train in luxuriously equipped palace cars, well supplied with all the comforts and luxuries of travel, and has abundant to eat and to drink, when trains reach their destination on time and distant friends can be communicated with by telegraph, and when the whole breadth can be compassed in a day or two ; such a traveller, I say, can know little of the toils, the discomforts, the hardships and the positive sufferings with which earlier travellers crossed it ; nor can he appreciate or even imagine the sufferings incident to the earlier explorations. The tragedies of those days seem to us as the creations of romance, and the tales of adventures and experiences seem as improbable as the story of the Arabian Nights.

Each of the continents has regions of interior drainage. Those in Asia and Africa are larger than ours, and there are various smaller ones, but the chief among them (unless it be the Sahara) so lie in the interior of the land that the waters flow from their borders outward to two or more oceans. Ours lies entirely in one continental slope ; that is, it is entirely surrounded by land which is drained to the Pacific.

These areas of interior drainage on the various continents vary greatly in their details of character, and have, in fact, but the one feature in common, that none of their waters flow to the sea. The term "Basin," which appears to have been first applied by Captain Bonneville to ours, has come to be used as a general term for them all, and is the descriptive term used in some text books in Physical Geography.

This use of the word is on the whole unfortunate in that it suggests a great error as to the actual character of such regions, and also suggests an erroneous cause for their existence. I find many people, otherwise intelligent, who have the idea, more or less vague, that the causes lie in the structure of the country, that there is a veritable basin or sunken area with a rim of mountains about it so high that the waters cannot get over the edge and flow outward to the great sea; that it is the rim which causes the basin and turns the waters inland to sink in the sand or evaporate from salt lakes in the enclosed and sunken interior.

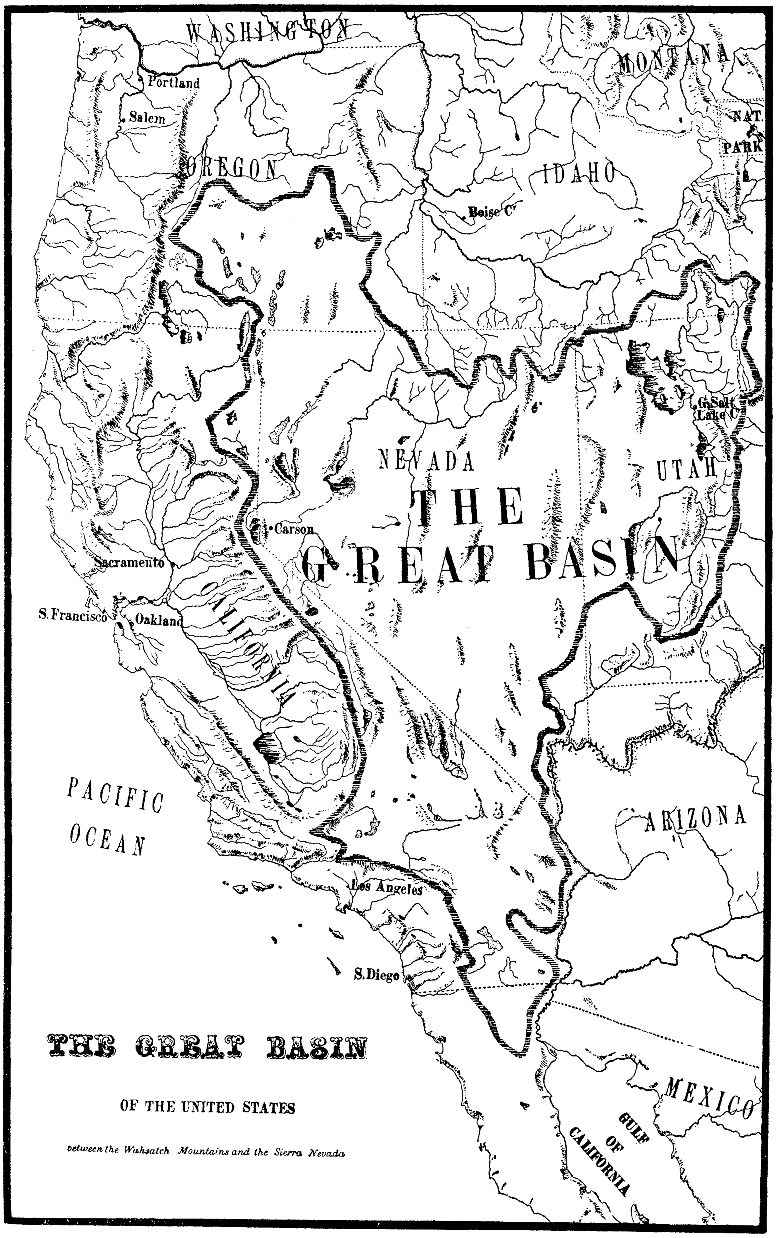
This misconception has been intensified by the fact that most travellers who cross it, find on one side the Rocky and the Wahsatch Mountains, and on the other, the still grander and higher Sierra Nevada. To such travellers the region seems obviously a basin with high mountains on either side which seem barrier enough to hold back the water, and a sufficient cause to prevent the rivers from ever reaching either the Atlantic or Pacific.

The real fact is, that it is not a basin of which the rim is an essential feature. The cause is climatic and not structural. It is in the air above it, and not in the rocks beneath it; it is the climate and not the geology or topography that makes the "Great Basin."

Pardon this elementary talk, but it must be kept in mind for an appreciation of the actual features of this remarkable region. It is a dry region, and it is the dry climate that makes the basin and not the basin that makes the dryness.

Whether a region of country is drained to the sea or not depends entirely upon the relative rain fall and evaporation, not at all upon its geographical structure nor how high a rim of mountains there may be around it, nor how deep its valleys may be. If more rain (or snow) falls on an area than evaporates from its surface, then the surplus water runs off in streams. If these streams run into a hollow with a rim, a lake will form in the lowest place, and the lake will increase in size until the evaporation from its surface will just balance the streams that run into it. Such is the case with the Great Salt Lake and the Caspian Sea. If more rain falls than can evaporate, then, give it time enough, the hollow will fill up and overflow, no matter how great the area, how high the rim, or how deep the depression. Most of the lakes of the earth are of this kind, from the mere pond to Lake Superior and the great lakes of tropical Africa. All such lakes have streams flowing into them fed by the rains and an outlet of fresh water running out. This must be so, whether the bed of the lake is below the sea level as is that of Lago Maggiore, and many of our own lakes, or whether as high as Lake Titicaca or the lakes on the borders of China.

Such fresh water lakes may lie within areas of interior drainage, their outlets running into the still lower lakes which are salt. Some such lakes are high above the sea, as are Tahoe in our own basin, and Titicaca in South America; others are low as is Lake Genessareth in Pal-


WASHINGTON
MONTANA
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IDAHO
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NEVADA
UTAH
THE GREAT BASIN
Carson
Sacramento
S. Francisco
Oakland
CALIFORNIA
PACIFIC OCEAN
ARIZONA
Los Angeles
S. Diego
MEXICO
GULF OF CALIFORNIA
THE GREAT BASIN
OF THE UNITED STATES
between the Wahsatch Mountains and the Sierra Nevada

estine, which is 850 feet below the level of the ocean, its overflow being into the still deeper depression of the Dead Sea.

The size of the salt lake in such a depression depends entirely upon the relations between the size of the streams which feed it and the evaporation from its surface. Should the streams increase for a series of years, the lake will rise and the surface increase. If the rains diminish then the lake also diminishes in area. The size of the lake does not depend on the size of the basin, nor on its height above the sea, nor on the height of its rim. The rim about the basin containing such lakes may be four miles high, as with some of the lakes on the Pamir, or it may be merely low sand hills but a few feet high, as is a portion of the rim of the Colorado Desert.

The lakes from which the last evaporation takes place in all these regions of interior drainage are salt, but they vary greatly in their saltness ; the one possible exception is Lake Tchad in the Soudan.

The salt in these lakes is usually not the pure salt used in our households, but a mixture of various compounds known to chemists under the general name of salts.

There are now in this American basin depressions in every stage of lake and dryness; fresh water lakes like Tahoe, of deep, cold, very clear, fresh water ; others like Pyramid Lake, brackish, but not salt enough to kill fresh water fish; others salt to saturation. Some are *playas* with water only after the rains of winter, drying up in summer to plains of glistening mud. In other valleys are expanses of shallow salt or alkaline water lasting throughout some years, but which sometimes dry up leaving only sheets of salt and alkali in the depressions. Still other valleys have great beds of salt, showing where lakes have entirely dried away, the beds of salt being their fossilized remains.

After this long introduction in elementary physical geography let us notice more particularly the features of the American Great Basin.

It lies between the Wahsatch Mountains on the east and the Sierra Nevada on the west, and extends about 12° of latitude, or from about latitude 44° in Oregon to about latitude 32° in Lower California.

I have plotted on the United States land office map the outlines and area of the Basin for our use here; by carefully following the line of divide around the whole area and then shading the region the better to show it. Its extreme length according to this map is about 900 miles, and the extreme breadth at right angles to the line of greatest length is about 520 miles.

Estimated from this map its total area is about 217,850 square miles. Mr. Russell, of the United States Geological Survey, in his monograph on Lake Lahontan, estimates the area at 208,500 square miles.

The States and Territories of this part of our country are of such great size that we, inhabitants of the smaller States, find it hard to appreciate this enormous area; but to do this we have only to mark a corresponding area (in shape and size) over the Eastern United States. If its northern portion be placed in Canada near Lake Huron and its eastern portion at the Hudson River and the Connecticut line, its southern point will be in Georgia and its western line extend through Tennessee, Kentucky, Indiana and Michigan. The whole area is nearly five times as large as the State of Ohio.

This great region is traversed by numerous mountain chains having a general north and south direction with valleys or plains between them. These mountain chains vary greatly in their geological structure, in their topography and in the aspects of their scenery. Some are so isolated that we can travel entirely around them, and others have some topographical connection with some other chain. They are of all heights, from the mere hill to peaks above 12,000 feet, and of various extent from the isolated butte to chains of several hundred miles in length.

The valleys between them have even greater variety of character. Some are fertile, others unmitigated deserts. Some are really high plateaus, as is that of the Great Salt Lake ; others are below the level of the sea, for in this Basin are found the lowest portions of the surface of the American continent.

The whole area is not one basin in the sense of one drainage area, one water-shed as engineers would say, but consists of many. All parts of the region are dry, most of the rain falls on the mountains and runs off into salt lakes or into the *playas* or "sinks." I know not how many drainage basins are combined to make this whole area, but there is certainly a score or more.

Bear in mind that if there was rain enough, all these lower places would fill with water until it ran over their respective rims. The drainage from the mountains would run down their slopes as now. A great number of lakes would be formed in the various valleys and their outlets would find their way to the Pacific by various routes. Some would empty northward to the Snake and Columbia Rivers, thence to the ocean ; some find their way westward through the Sierra Nevada by way of the Klamath Valley ; some southward into the Colorado River or the Gulf of California ; and possibly still others across Southern California to the ocean.

But, over the whole region the actual rain-fall is vastly less than can be evaporated from the surface and this scantiness of rain-fall is the all-controlling factor as to its agricultural resources and its fitness for the homes of men.

The economic foundation of civilization is agriculture, and for agriculture there must be rain in considerable quantities, at least in occasional years. Crops may be grown for a time by irrigation in a rainless region, but they cannot be so grown for an indefinite period. The same causes which make lakes salt or alkaline if there be no outlet ultimately make soils also salt or alkaline, and this causes barrenness.

Streams always contain a small proportion of certain salts which have been washed out from the soils from which the waters come. Where these run into closed lakes, and the water is evaporated from the surface, the salt is left behind, thus making the lake salt. The character of the salt depends upon the chemical character of the soil of the water-shed. In the same way where the water of rivers or streams is used for irrigation, if all the water is evaporated from the cultivated soil, injurious salts are left behind which accumulate and finally destroy the fertility of the land and turn it back again into a desert. For irrigation to be permanently successful, there must be some rain, and in occasional years a sufficient water to wash out and carry the deleterious salts away.

Every where in the Eastern United States, more rain falls upon the land than can evaporate from it. In New England, New York and the region east of the Mississippi, one year with another, from 40 to 70 per cent. of the rainfall flows away to the sea, and the soils of such localities may be perpetually fertile.

West of the Mississippi a smaller proportion flows to the sea; but over all the region east of the 100th meridian some of the rainfall of every year flows from the land; there are but few places in the United States outside of the Great Basin, where some of the rainfall of occasional years does not flow away. Over large portions of the Great Basin, the rainfall is so slight that there is neither water for irrigation nor the conditions for permanent fertility, even if waters could be found. There are, however, many isolated districts that are fertile and may be irrigated.

The mineral wealth of the region, however, is vast; it is indeed wonderful both in variety and in richness; but mineral wealth alone and of the kinds most common in the Great Basin has never yet made a permanently prosperous State.

The truly prosperous State must be a country of homes, and this occurs only where agriculture can be praticed on a considerable proportion of the land. On a relatively large proportion of the American basin agriculture is not possible. It can never support at best more than a relatively small agricultural population, although there are scattered spots of great fertility and some of marvellous beauty.

This region was not always so dry. In the geological age just preceding the present one, there was a period during which our Northern hemisphere was much colder and the climate much wetter than now. It was called the Glacial period, and ice covered much of the Northern hemisphere. Geologists tell us that it covered all New England and New York, the Southern edge of the great glacier reaching down into Pennsylvania and Southern Ohio in the Eastern United States. Then there were also stupendous glaciers in the Western mountains. They have left their traces everywhere. Glaciers sometimes a mile thick and several miles wide filled the valleys of the Sierra Nevada, and extended down into the Basin, their great moraines at the mouths of the numerous cañons still testifying of their great extent and volume. Incident to this period, both before and after it, there was abundant water in the Great Basin.

Lakes then existed there, some of great size, and from the nature of the country they must have been of marvellous beauty. Geologists have especially interested themselves in the study of the history of two of these lakes, one in the western part known as Lake Lahontan, another farther east called Lake Bonneville. The great Salt Lake is what is left of the latter; the former is dried away to a few shallow salt lakes or to dry deserts. This western Lake Lahontan has been made the subject of a special monograph by Mr. Russell, of the United States Geological Survey. According to this authority its area was at least 8,400 square miles, (or a little larger than the area of the State of Massachusetts). We find if we look at a copy of its map that the lake was more irregular in shape than any large lake at present known upon the globe, its outlines deeply indented by numerous mountain chains extending far into it, and irregular islands, one of large size, dotted its surface. Although a fresh water lake, it is thought to have had no outlet; that it began to dry away and disappear before the depression was entirely filled to overflowing. With a change in climate it has dried away; about a half a dozen lakes more or less salt occupying some of the lower depressions, other parts of its bed being occupied by "*playas*" or alkaline "sinks," which are unmitigated deserts.

The chief of these lakes are Walker's Lake, South and North Carson Lakes, Pyramid Lake, Winnemucca Lake, Honey Lake, and Eagle Lake; and the two most notable deserts are the Black Rock desert in the North and the Carson desert in the South.

There are several fresh water lakes within the watershed of this ancient lake, the most important and noteworthy of which is Lake Tahoe. This lake, so justly celebrated for its beauty, lies at the eastern base of the Sierra Nevada at an elevation of about 6,000 feet. It is more than 1,500 feet deep, its cold waters are of great clearness, and the Sierra rising boldly from its western shore to peaks of 10,000 feet makes it one of the most picturesque lakes of the continent. Its outlet, the Truckee River, runs chiefly into Pyramid Lake and Winnemucca Lake.

With the change of climate, Lake Lahontan slowly disappeared by drying up; its successive shores constitute a conspicuous feature of the landscape, and, as already stated, all that is left are the few salt and brackish lakes and beds of salt and alkali scattered here and there in the lower depressions.

During the existence of this lake the region was subject to volcanic eruptions and probably to changes in level incident to such disturbances. Volcanic activity then existed in many parts of the region within and beyond its actual borders, and numerous mineral springs yielded the various products found in volcanic countries. The chemistry of the drying up of this lake is therefore as interesting as is its geology. There is a curious variety of salts found; here a swamp, in which are buried inexhaustible quantities of crystals of borax; there, plains covered with alkaline efflorescence like snow; again, there are lakes of carbonate of soda; Mono Lake, just beyond the old lake, is a nearly saturated solution of salt, soda, borax and other chemicals. When camped on its shores we found its waters as efficacious in washing our woollens as the best soap-suds, and the barbers of Esmeralda used it for shampooing.

Many springs made deposits of tufa, and some of the tufa masses are of extraordinary, not to say, grotesque shapes, of which illustrations may be found in photographs.

Mono Lake is thought by Mr. Russell to lie outside of this old lake basin, but at the time of my earlier visit I believed it to have been included.

During the existence of Lake Lahontan, extensive beds of sediment were laid down upon its bottom, which beds have been again furrowed by the erosion of the modern rivers which now flow over what was then the lake bottom, and have cut into the strata of the old lake bed.

This sediment is in part such as is generally washed from mountains and in part the volcanic ashes and dust which was rained upon this region from the neighboring craters and sank as an impalpable powder in its waters. Mr. Russell gives a wood-cut in which volcanic dust from various other sources and from these ancient sediments is brought together and compared. The resemblance between this old Lahontan dust and that from Norway in 1875 and Krakatoa in 1883 is very obvious.

Of the various volcanoes of this region or its borders, the cones and extinct craters of Lake Mono are perhaps the most remarkable. The views of them in published works are from the photographs of Mr. King; I climbed them in 1863; their steep sides are largely of loose sand and pumice, and in the material there is much variety both as to color and texture; obsidian or volcanic glass is also very abundant and of many colors. What interested me more than any other feature of these cones was the finding of a few fragments of granite, roasted and altered by volcanic heat within these craters; they had not been left there by the glaciers. and I am not aware of similar productions having been found elsewhere. They must have been cast up in the later stages of the eruption, but precisely how they could have been thus torn loose from their original position and left as we found them is indeed difficult to understand.

The scenery of this immediate region is sufficiently striking. The steep volcanic cones with a few scattered and stunted cedars and nut-pines, the unmitigated desert at their base with the ever present sage brush and grease wood; Mono Lake itself, 6,000 feet above the sea, its heavy waters strangely placid and smooth; the great Sierra beyond, like a wall against the sky; the Mt. Dana group rising precipitously from the lake to above 13,000 feet and streaked with snows above; the great moraines stretching out from the mouths of the cañons upon the desert at the base, constitute altogether a picture so unlike anything we have elsewhere in the United States, so unlike anything and everything we have east of the Mississippi River, that it leaves an impression on the mind of even greater desolation and barrenness than actually is the case.

The average rain-fall of the basin as a whole has been variously estimated, but no one places it higher than twelve or fifteen inches annually. In the plains and valleys the average is vastly less ; sometimes several years passing without practically any rain-fall in some of the valleys and it is probable that in some places the average is less than an inch per year. But so far as I know there is no portion absolutely rainless. The rains, however, are very uncertain, and some regions are subject to occasional severe local showers known as "cloud-bursts." These are simply extremely local, heavy showers in which several inches of rain may fall in a limited region, and within a few minutes. The waters gather in the ravines down which they rush many feet deep, with resistless force bearing on their surface the various light objects picked up in their impetuous course, and sometimes excavating gullies many feet in depth within a short time. The stream ceases almost as suddenly as it came. Many such have been recorded, some of which have been very fatal to persons travelling in the region in which they occur.

The dryness of the air, the cloudless sky, the capricious winds, the local whirlwinds which carry up dust, all conspire to give a peculiar beauty and wonderful variety to the atmospheric aspects of the scenery.

Sometimes, particularly in winter, the atmosphere is of marvellous clearness and transparency, objects a hundred or more miles away being clearly and sharply discernible from the peaks within the basin or about its borders. But through the most of the summer season a haze, composed of fine dust, fills the air so that it is much less transparent.

Many of you may remember the remarkable sunsets and "sky-glows" of the autumn of 1883, which were believed to have been produced by fine volcanic dust in the upper regions of the atmosphere brought from the distant eruptions of Krakatoa.

What was then believed to have taken place on a world-wide scale, so far as its effect on the colors of the sky and in producing various optical phenomena relating to the atmosphere was concerned, certainly does take place on a smaller scale, but in a greater variety in the atmosphere over the Great Basin. There is a charming variety of colors induced by the fine dust particles in the air, either by polarization, by diffraction, or other decompositions of the light. There are sunset glows of various colors and there are mid-day glows. We have skies of blue and we have green skies, and purple and pink and various shades of yellow, and so on through many colors and effects, which were it possible to portray on canvas, we would pronounce to be wholly unnatural, however beautiful.

When in the mountains along the western rim and looking out over the deserts and beyond the successive mountain chains to the east of us, this play of colors and varying aspects of the sky was of never failing interest.

And now a few words as to the native vegetation of this region. Popularly, deserts are supposed to be without vegetation. Practically, if there is absolutely no rain nor water, there can be, of course, no vegetation; but if a region have some rain, even though it may be at long intervals, there will be plants of some kind.

The species of the Great Basin are largely shrubby and adapted to the dryness and heat they are liable to be subjected to. The species of our climate are of kinds that cannot stand protracted drought; they die when dried, but desert plants retain with great tenacity a sufficient amount of moisture to preserve their life, although they may suspend their vegetative functions for a very long period. Let me illustrate. You are all familiar with the lichens of our climate, growing on the rocks, fence-rails, etc., which in rainy weather are flexible, filled with water, and grow; in a drought they dry so completely that they are brittle and may be pulverized to a powder in the hand, but yet they are not dead; no more dead than a seed; they only require water to again sprout and grow, and when rains come they imbibe moisture again, become flexible, their sap circulates and they grow and increase in size until the next drought comes to again dry them out and suspend their growth. They rest during the drought as other plants do during the cold winter. Their functions are merely dormant, they are not dead. So these desert plants cease their growth during the long and excessive droughts to which they are subjected. These species (for there are many kinds), have usually small leaves, the wood is usually hard and brittle; they grow when there chances to be sufficient moisture and when the severe droughts come on them suspend their growth as our trees do in winter, and await better times.

I was in one valley between two high mountain ranges; the valley itself 4,000 feet above the level of the sea, where there had been less than three-quarters of an inch of rain during the previous eighteen months, and where we found the heat in July from 100 to 110 in the coolest places we could find, and yet this desert was not bare; clumps of shrubs grew every few rods, sage brush on the slopes, grease wood where the soil was alkaline, and various other species. Some of these were so dry that they would readily burn when a match was applied; we could not call them "green" but surely they were not dead. The creosote bush grows in the more southern deserts, vile-smelling, with sticky, stinking leaves, so repulsive that it is said even the camels will not touch it. In justice to the camel I should say that this fact has been denied. One of the men who had charge of the camels introduced by Jefferson Davis, and tested on these deserts, told me that the camels did eat sparingly of even the creosote brush.

How long some of these shrubs can survive without rain, I have no idea, but one herbaceous plant, the *Lewisea Rediviva*, found on some of the drier peaks northward, after having been dried as completely as I could do it for herbarium specimens, continued to sprout and grow in the papers in my herbarium in New Haven, for several years afterwards. A botanical journal, some years ago, made a report of plants that had blossomed after the exceptional rains which fell on a portion of the desert of Atacama in South America, after fifteen rainless years. I know of no such tests regarding our own desert plants, but I have no doubt whatever in my own mind but that there are a number of species to be found within our own Basin, that would live through several rainless years.

There are regions, however, that are practically without vegetation; and several of these are pictured in the Government reports of explorations. Some are alkaline "sinks," others drifting sand, still others areas kept barren by hot springs.

Among these are sand-hills taken from a photograph near the 40th parallel where they stretch for many miles; but drifting sands occur in many other places, sometimes polishing and carving rocks over which they blow. This is especially true on the Mojave and Colorado Deserts where this phenomenon, first noticed by Prof. Blake, has since been noted by many observers.

But in considering this barrenness and desolation, we must remember that there are many spots of great beauty and fertility. These are always near streams at the base of mountains. Even in the barren Owens Valley there are fertile spots, and the unmitigated desert is easily changed into a garden by irrigation, where water of the proper quality and quantity can be obtained. Those who have seen the Carson Valley, with its prosperous farms and green fields and background of high Sierra, must recall it as a beautiful picture.

The mountain scenery is of even greater variety than that found in the valleys; as already stated, the Basin is traversed by numerous mountain chains; and these have every variety of geological structure and every character of rock. Some are volcanic and there is a great variety of volcanic products; here, soft stratified tufas, there, great lava flows, and again cones of ashes and cinders. There are mountains of trap and basalt, sometimes as columnar as that of the Giant's Causway.

Owing to the peculiar climatic conditions, the erosions and denudations of these mountains are peculiar. The ridges are sharp, the cañons V shaped. As they are rarely clothed with forests and often practically bare of trees, the whole of their elaborate sculpture is plainly discernible. They rise naked from the barren deserts, every ridge of their skeleton evident. In winter these views are even more striking than in summer. I have in mind a view after a recent snow, too light to cover the plain, but heavy enough on the mountains to completely whiten them. The naked, barren chain seemed as white as if carved in the whitest marble, its every ridge coldly clean, scarcely specked with tree or bush, its every ravine distinct, its serrated crest white and sharply cut against the blue wintry sky, the whole rising from the brown, desolate, sage-plain, presenting an aspect as unlike that of forest covered mountains, as if it belonged to another planet.

There are also mountains of soft strata ; mountains of hard, metamorphic rock, twisted and broken ; we have them of great variety of aspect, but, as a whole, they lack the rounded outlines, the covering of forest and the green of eastern mountains. We can hardly call them *Alpine*, because Alp strictly means an upland pasture. The green pastures which are such a characteristic feature of the mountains of Central Europe that they give their name to the mountains themselves are here entirely absent. In fact, one sees little green ; it is said that in the whole State of Nevada, embracing over 100,000 square miles, that "there is only one spot where for more than six square miles together, the landscape is naturally green."

In the southwestern portion of the Great Basin are two or three remarkable depressions. One known as Death Valley lies near the eastern borders of California, only about 70 miles southeasterly from Mt. Whitney, the highest land in the United States. This valley is the sink of the Amargosa River, and was formerly believed to be the lowest on the American continent. Its precise depth below the sea-level has not been very accurately determined, the later statements making it 225 feet, although other accounts make it much deeper.

It gets its dreadful name because of the emigrants who have perished there. It is near one of the old trails which led into Southern California; and emigrants have been decoyed into it hoping to find water, and there perished.

A portion of the Colorado Desert, often called the San Bernardino Desert, the sink of the San Felipe is also a great depression below the level of the sea, probably deeper even than Death Valley. The portion below the level of the sea is said to be about 130 miles long by 30 wide, and the lower parts 360 feet below sea level. These figures are given from popular statements rather than official surveys. It, too, was the bed of a lake as no very distant period, and the old shore lines are strikingly distinct againts the sides of the surrounding mountains. Some interesting views of this feature may be found in the old Pacific Railroad Reports. The present Southern Pacific Railroad traverses this depression for many miles.

Portions of the eastern rim of this part of the Basin are merely low sand-hills separating the depression from the Colorado River and the Gulf of California. There have been various projects for flooding this region at the expense of the United States Government, and creating an interior lake which might fertilize a portion of the desert and modify the climate of Arizona. I have no faith in the practicability of the scheme.

Before leaving the western portions of the Basin, let me add a few more words regarding the variety of salts found in solution in the lakes or crystallized in the depressions. The country being more or less volcanic, we have the natural source for a great variety of products. The famous Soda Lakes near Ragtown in Churchill Co., Nevada occupy ancient craters ; they are solutions of carbonate of soda and for many years have been worked for this material, producing some hundreds of tons annually. It is estimated that this lake contains nearly a million of tons of the carbonate of soda and sulphate of soda. Carbonate of soda is also obtained from various other lakes of the basin and borax from several places. Salt is also obtained in numerous localities ; in some by evaporating the waters, and in other places rock salt of great purity is quarried from extensive beds.

Various other chemicals are found of great interest to chemists and mineralogists but of less economic importance. In the remains of some of these old lakes, gigantic crystals of a peculiar mineral called Thinolite are found which belongs exclusively to this region.

Nor must the numerous hot springs of the region be forgotten : I can attempt no enumeration of their number. Among the more famous are the Steamboat Springs near Virginia City. Here steam and hot water escape from cracks several miles in extent, and the silica and other mineral matter dissolved in the hot water, when deposited and cooled at the surface, have formed great mounds several hundred feet high and several miles in extent.

As these mineralized waters flow over the surface, they incrust or "petrify" various objects found there; even such frail organisms as crickets and flies are incased in silica, which is gelatinous at first but which ultimately hardens. Some of the hot springs have a reputation for medicinal qualities, and doubtless there are many which would be a fortune to the owner if located in some convenient locality east of the Mississippi River.

I have spent so much time considering the western portion of the Great Basin and the ancient Lake Lahontan, that I have less space left to me than I could wish for the consideration of that other and larger ancient lake, Lake Bonneville. This lake washed the western base of the Wahsatch Mountains, and it was as irregular in shape as Lake Lahontan. Its shores were indented with numerous promontories, and many bold and picturesque islands rose from its surface. It had an area of about 19,750 square miles or was nearly twice as large as Lake Erie. Bear River, the Weber, Provo, and Sevier Rivers, and other large streams from the Wahsatch flowed into it from the east.

This lake had an outlet northward through the present Red Rock Pass at the north end of the Cache Valley in Idaho, and thence to the Pacific by way of the Snake and Columbia Rivers. It has dried away, and the Great

Salt Lake is all that is left of it. It did not disappear regularly, but by successive stages and the terraces left, which mark its ancient shores, are the most striking features that meet the eye of the traveller about Salt Lake, and far to the southward in Utah.

Some portions of this old lake bed now constitute tolerably fertile valleys, watered by fresh rivers, but other portions are totally barren. The great plain lying to the west and southwest of Salt Lake is probably the most unmitigated desert of equal size to be found within the limits of the United States.

The present area of the Great Salt Lake is between three and four thousand square miles, but its size is fluctuating. It has risen and covers several hundred square miles more of surface than it did at the time of its first survey by Lieutenant Stansbury in 1849.

When the Pacific Railroad was finished twenty years later, or in 1869, the lake was said to cover 400 square miles more than it did at the first survey. Some increase has taken place since, and it is known that the surface of Salt Lake is higher and the waters deeper than forty years ago. The early Mormon settlers could ford the lake to Antelope Island ; it is utterly impossible to do so at the present time.

This increase of water is not due to settlement and cultivation, but is doubtless due to some secular change in the rainfall on the mountains. The cultivation is mostly in the valleys, while the rainfall is mostly in the mountains. There are very many views illustrating the terraced shores of this old lake, but the effect on the observer of the actual facts is vastly more impressive than any views can be.

The great changes in climate which have produced the wonderful results described as occurring in our American basin are probably simultaneous with similar changes going on over much of the Northern hemisphere. The ruins of towns south of this region, the old Pueblos show that the drying up has extended in our own continent far beyond the present boundaries of the Great Basin, and similar changes have apparently gone on simultaneously with this in the Old World. The Caspian Sea lies below the present level of the ocean, and in its vicinity the drying up has been going on even in historic times. We have historic evidences of great populations where now is desert, and farther east in the same area of interior drainage there are evidences of great dried up lakes.

Lake Bonneville had an outlet. Of this there is no question, and we may believe that the overflow was very considerable. As stated earlier in this paper, the United States Geological Survey thinks that Lake La hontan had no outlet, and explains how the lake in drying up may have been freshened after the deposit of some of its salts by evaporation. I must confess that I strongly suspect that more complete exploration and investigation will ultimately show that it, too, had an outlet. It would surely be a wonderful thing if the period of rains and of successive dryness should have been so evenly balanced that the depression should run so nearly full and yet never overflow. I do not pretend to say where this outlet was, nevertheless I believe it to have existed. Moreover, my own and less complete observations made about Lake Mono many years ago led me then to believe that Lake Mono had, at some period, a much higher level than has since been attributed to it; and, if I was not mistaken in my observations then, the area of Lake Lahontan may have been considerably larger even than that now attributed to it.

In considering the resources of the Basin as a whole, I do not wish to be misunderstood. The aggregate resources must be very considerable, the most striking portion of which will remain in its mineral productions; its great mineral wealth has brought to it its chief economical reputation. Its mines have yielded such quantities of precious metals that the finances of the world have been changed, and its production of silver led to the demonetization of that metal. The great Comstock Lode has been the locality of the greatest mines of modern times, and has led to more romantic and famous changes of fortune than the mines of any other part of the world during the same time.

It is unnecessary to compare its many mines with those of Mexico and Peru, but it is safe to say that they have had more to do with the finances of the world during the last twenty-five years than any others on the globe.

Regarding the agricultural possibilities, I repeat, it must ever remain a region of relatively sparse population. The portion in Utah has more popular interest in this regard because of its settlement by the Mormons. The geographical features of the region have been eminently adapted to the growth of such a religious system. It has been a law of the development of independent communities that they needed isolation for their early development, and also natural protection in their isolation. Persecuted and despoiled in the older and more densely populated eastern States, the Mormons fled to a place of safety. "To build up Zion in the wilderness," they journeyed across the plains, passed through the mountains and settled here, far beyond the borders of civilization. Taking possession of the places better suited for their use, living in village communities, by irrigation they reclaimed portions of the arid soil, and made the desert indeed blossom as the rose.

It was especially suited to their conditions, that is, it had the physical characters and political situation to recommend it to a peculiar and persecuted people. When they emigrated this region was believed to be beyond the jurisdiction of the United States, and practically beyond the interference of Mexico ; political isolation seemed, therefore, secured, and the mountains and the deserts about it were a protection against marauding outlaws and outside people seeking conquest. The land could be reclaimed and made extremely fertile by peoples living in communities, as did the Mormons. It was not adapted to settlement by the gradual pushing of the frontier line, as was the case in the more fertile western States. I need not follow up this wonderful story (which for personal reasons has always had a fascinating interest to me) further than to say that we find in the physical condition of the country one of the reasons for the success of this most wonderful religious movement and most astonishing delusion of modern times.

When I contemplated writing a paper on this subject I intended to have had much more to say regarding the early history and explorations in the basin, and the development of our knowledge regarding it. Many itemsof information picked up more than a quarter of a century ago from the actors in the scenes and from individuals now passed away, might make an interesting chapter of more or less disconnected fragments of this early history; but a recent examination of the literature relating to our western country has shown me that many of the items of history which I believed only existed in tradition, or in the memory of the older explorers, have found their way into print into one form or another and hence need not be repeated for record here.

This Basin, while still containing many nooks and corners to be mapped and explored, is nevertheless the best known by far of the areas of internal drainage in any of the continents. Of the two greater ones, the Sahara in Africa and the still larger one in Central Asia, we still have but very imperfect geographical knowledge. Ours was the first to know a railroad, the Union and Central Pacific roads being finished across it in 1869, and portions of it are now crossed entirely by several railways. Branches from these penetrate to the interior by various routes and there are now within it many hundreds of miles of railway; I have made no attempt to estimate how many, but persons can now travel with ease and luxury where scarcely a generation ago only the most hardy could survive the hardships of travel, and towns have grown up where then were deserts.

In conclusion I will repeat that the Great Basin must ever remain a region of relatively sparse population, because of its scanty rain-fall.

In any region far from the sea the capacity for supporting a population depends upon the rain-fall or the possibilities for irrigation, and in this area there are many localities of great beauty and fertility that can be irrigated, but all are relatively small when compared with the total area. In these limited districts there will be ultimately many beautiful places that will be noted for their picturesqueness, for their salubrious climate and the richness and variety of their productions, but at best they can never constitute more than a very small portion of the whole region.

There is some pasturage in the regions not adapted to cultivation where herds and flocks, more or less nomadic, have been pastured and will continue to be grown as in other dry regions, but the capacity of the country in this direction is small as compared with the regions favored with more abundant rains.

The wealth of its mineral resources has been alluded to at various times in this paper. This is justly celebrated because of its great variety and enormous abundance. When I first visited the State twenty-four years ago, there were then recorded an almost innumerable number of mining claims and it was said that more than six thousand mining companies were then in existence. While but a very small proportion of this vast number have proved profitable, it is still true that many towns, villages, and even cities have been built up at various mining centres. But mineral wealth alone, especially if of the precious metals, never builds up a continuously prosperous State; that is only founded on agriculture where people wish to build permanent homes.

The romances of sudden and great wealth, acquired from the mines in these regions by persons earlier in humble circumstances, are familiar to the whole world. Some, who began as poor laborers and low in the social scale, but who have died among the millionaires, are known the world over, yet such do not make a prosperous State. Nevada, the only State within the basin, has steadily declined in population in late years, until now the entire population on its more than 100,000 square miles would scarcely be sufficient for a fifth-rate eastern city. The very men who have made great fortunes in Nevada go elsewhere to enjoy their wealth notwithstanding its healthy climate, and I fear this will be the case for a long time to come. Nevertheless because of the abundance and the wide distribution of mineral wealth, the mineral resources of the basin must ever continue to be great in the aggregate.

Portions of this subject have grown to greater length than I intended, because of the richness of the matter, and I have scarcely alluded to several items that I had desired to speak of more in detail. One is the exceedingly rapid evaporation that takes place or may take place from its soils and its lakes. By actual experiment it has been found in some places to be a half an inch per day or fifteen inches per month, and it is no wonder that under such conditions large portions are desert.

In certain places Artesian wells are practicable, but inasmuch as their capacity depends upon the amount of water falling on the mountains or hills which constitutes the source of their supply, they can never be of extensive use or success except in very limited areas. They may however be the means of making the establishment of stopping places and stations practicable in regions now difficult to be traversed because of the long stretches between existing supplies of water.

In conclusion I will say it must ever be a region of peculiar interest to the geologist, the botanist and the mineralogist, and will be more and more visited by general tourists in search of new scenery and aspects of nature unlike those found in more rainy regions; that while as a whole it can never have more that a sparse population as related to its size, yet because of its vast area, and because of the great fertility of particular spots, it probably will have ultimately a very considerable population in the aggregate. It will have here and there localities which will become places of resort for those seeking health, for those suffering with ailments which are benefitted by a dry and warm climate. It will ever be an intensely interesting region because of its strong contrasts between inhospitable desert and productive fertility; and despite its general desolation it will be visited because of its inherent and especial beauty.

Yale University, December, 1888.